STRATASCAN

Geophysical Survey Report

Biddulph Old Hall, Biddulph Staffordshire

For

Nigel Daly Design

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J2058

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LIST OF FIGURES

1 SUMMARY OF RESULTS

Detailed Resisitivity and Ground Penetrating Radar surveys were carried out at Biddulph Old Hall. The site was broken down into three separate survey areas, an area within the ruins of the mansion (Area 1), an area known as the tilt yard (Area 2) and an area located to the west of the house (Area 3). The resistivity and GPR surveys have identified corresponding anomalies that may indicate a number of structural remains present within the mansion (Area 1). The tilt yard (Area 2) was of limited success with few detailed anomalies of possible archaeological origin being identified. However, the GPR has identified areas of possible structural debris and landscaping, whilst the resistivity has identified possible areas archaeological activity. Area 3, west of the house, has identified a few weak anomalies that may relate to archaeological activity and a number of possible services.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Nigel Daly Design to undertake a geophysical survey at Biddulph Old Hall. The survey forms part of an archaeological investigation of Biddulph Old Hall and its surroundings.

2.2 Site location

The site is located at Biddulph Old Hall, Biddulph, Staffordshire at OS NGR ref. SJ 895 603.

2.3 Description of site

The survey area is 2200m² in size. The survey comprises of a garden area within the ruins of the mansion, an area known as the tilt yard situated south of the mansion and an area located to the west of the current house. All areas comprised of cut grass with flat topography.

The underlying geology is Lower Westphalian with overlying Boulder Clay and Morainic Drift (British Geological Survey South Sheet, Fourth Edition Solid, 2001 and British Geological Survey South Sheet, First Edition Quaternary, 1977). The overlying soils are Rivington 1 which are typical brown earths. These consist of Carboniferous and Jurassic sandstone and are well drained coarse loamy soils over sandstone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.4 Site history and archaeological potential

The survey was conducted within and around the ruined mansion of Biddulph Old Hall, a registered Scheduled Ancient Monument (no. 21636). The Hall was built in 1580 but was destroyed during the civil war, leaving only three external walls standing.

The potential for structural remains within the hall is high. The area to the south of the mansion (known as the tilt yard) may contain the remains of previous garden architecture, such as raised walkways or parterres.

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological origin, to investigate the original features of Biddulph Old Hall.

2.6 Survey methods

Two survey techniques were used within the survey areas to identify potential structural remains and anomalies of archaeological origin. A resistivity survey was carried out at 0.5m centres within the mansion (Area 1) and at 1m centres within the tilt yard (Area 2). Ground Probing Radar (GPR) was also used within the mansion (Area 1) to help identify possible buried structures and their depths. An area within the tilt yard (Area 2) and a small area west of the present house (Area 3) was also surveyed with GPR.

More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over 3 days from the 15-16th September and the 6th of October 2005. The weather was variable with infrequent showers.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2.

3.3 Description of techniques and equipment configurations

Resistivity
This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

Radar

Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments and which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

The Ground Probing Impulse Radar used was a SIR2000 system manufactured by Geophysical Survey Systems Inc. (GSSI).

The radar surveys were carried out with a 400MHz antenna. This mid-range frequency offers a good combination of depth of penetration and resolution.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Resistivity

The readings were taken at 0.5m centres along traverses 0.5m apart within the mansion ruins. This equates to 3600 sampling points in a full 30m x 30 grid. Whilst the Tilt Yard readings were taken at 1m centres along traverses 1m apart. This equates to 900 sampling points in a full 30 x 30 grid. All traverses were surveyed in a “zigzag” mode.

Radar
Radar scans were carried out along traverses 0.5 m apart on a parallel grid as shown in Figure 2. Data was collected at 60 scans/metre. A measuring wheel was used to put markers into the recorded radargram at 1m centres.

3.4.2 Depth of scan and resolution

Resistivity
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m. The collection of data at 1m centres with 0.5m probe spacing provides an optimum resolution for the technique.

Radar
The average velocity of the radar pulse is calculated to be 0.072/nsec which is typical for the type of sub-soils on the site. With a range setting of 60nsec this equates to a maximum depth of scan of 2.15m respectively but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

3.4.3 Data capture

Resistivity
The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

Radar
Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Resistivity
The processing was carried out using specialist software known as *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 3*
	Y radius = 3
	Weighting = Uniform

Radar
The radar plots included in this report have been produced from the recorded data using Radan software. Filters were applied to the data to remove background noise.

3.5.2 Presentation of results and interpretation

Resistivity
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figures 3 and 4); together with a grey scale plot of the processed data (Figures 5 and 6). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (Figure 7).

Radar
Manual abstraction
Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams.

i. Strong and weak discrete reflector.
These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

ii. Complex reflectors.
These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

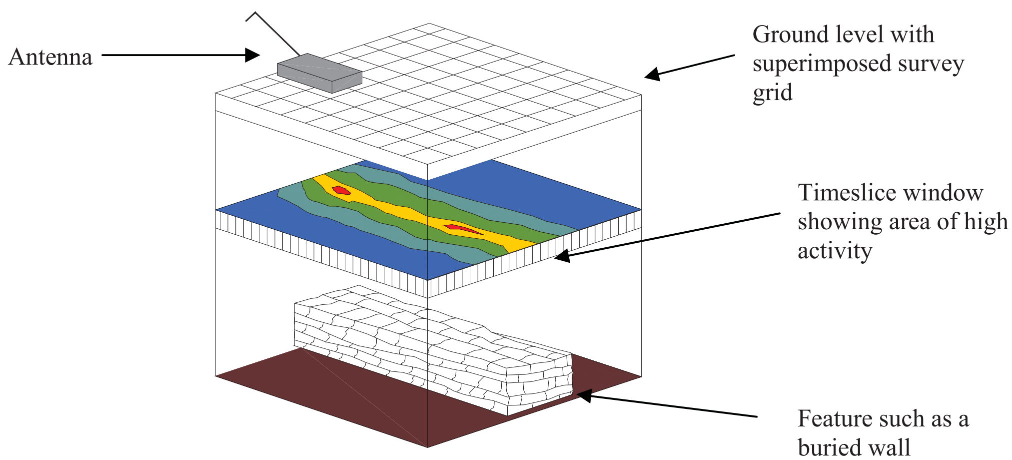
iii. Point diffractions.
These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in 4. below).

iv. Convex reflectors and broad crested diffractions.
A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.
These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

Timeslice plots

In addition to a manual abstraction from the radargrams, a computer analysis was also carried out. The radar data is interrogated for areas of high activity and the results presented in a plan format known as timeslice plots (Figures 8-10). In this way it is easy to see if the high activity areas form recognisable patterns.



The GPR data is compiled to create a 3D file. This 3D file can be manipulated to view the data from any angle and at any depth within range. The data was then modelled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report. Based on an average velocity calculations have been made to show the equivalent depth into the ground. The data was sampled between different time intervals effectively producing plans at different depths into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white (see key provided in Figures 8-10).

Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

4 RESULTS

4.1 Resistivity

The resistivity survey carried out within the ruined mansion walls have produced a number of linear area anomalies that may relate to structural remains. The resistivity survey within the tilt yard has produced less substantial evidence for potential archaeological remains. A wide range of anomalies have been identified across both survey areas and can be divided into the following categories.

Area 1 - The mansion

- High resistance area anomalies possibly relating to structural remains of archaeological origin
- Moderate high resistance area anomalies possible relating to structural remains of archaeological origin
- Moderate high resistance linear anomalies possible relating to structural remains of archaeological origin
- Moderate high resistance area anomalies possible relating to structural debris
- Low resistance area anomalies possibly relating to cut features of archaeological origin

Area2 - The tilt yard

- Faint high resistance linear anomaly – structural remains or compacted ground of possible archaeological origin
- High resistance area anomaly possibly caused by nearby vegetation and tree roots
- High resistance area anomalies of possible archaeological origin
- Moderate high resistance area anomalies of possible archaeological origin
- Low resistance area anomaly relating to pathway
- Low resistance area anomalies of unknown origin
- Faint low resistance area anomalies of unknown origin

Area 1 - The mansion (see Figure 7)

High resistance area anomalies – possible structural remains
Ten distinct areas of high resistance have been identified with the mansion (**A-E**, **H**). These anomalies may represent possible structural remains; identifying previously existing structural remains of Old Biddulph Hall. Two possible doorways may be identified between the high resistance anomalies **D1** and **D2** and **E1** and **E2**. Anomaly **D2** suggests the continuation of an internal wall from a standing structure situated along the south wall of the mansion. Anomalies **H1** and **H2** may represent structural remains or are caused by the construction of the nearby pathway.

Moderate high resistance area anomalies – possible structural remains
Two areas of moderate high resistance anomalies have been identified with the mansion in a north to south orientation (**F** and **I**). Anomaly **F**, situated toward the western side of the mansion, may relate to a possible internal wall. Anomaly **I** may relate to structural remains or debris from the destroyed external eastern wall.

Moderate high resistance linear anomalies – possible structural remains
Three moderate high linear anomalies have been identified running perpendicular off area anomaly **F** (**G1-3**). These anomalies represent weak evidence for further partitioning within the mansion.

Moderate high resistance area anomalies – possible structural debris
A large area of moderate high resistance can be identified within the southwest corner of the mansion (**J**). This anomaly may represent a large area of structural debris.

Low resistance area anomalies – possible cut features of archaeological origin
Two areas of low resistance can be identified close to the north and west walls of the mansion (**K** and **L**). Both anomalies are situated close to a window within the external walls and may represent cut features possibly associated with the robbing of materials.

Area 2 - The tilt yard (see Figure 7)

Faint high resistance linear anomaly – possible compacted ground or structural remains
A faint high resistance linear anomaly has been identified in the south of the tilt yard (**S**). This anomaly may represent and an area of compacted ground or weak evidence for structural remains, possibly relating to a previous garden layout.

High resistance area anomaly – possibly caused by vegetation and tree roots
An area of high resistance can be identified around the southern perimeter of the survey area (**N**). This anomaly is possibly caused by the presence of nearby vegetation and tree roots.

High resistance area anomaly of possible archaeological origin
Three areas of high resistance can be identified within the tilt yard (**M**, **O1** and **O2**). Anomaly **M**, situated towards the north of the survey area may represent a possible bank or boundary of archaeological origin. Anomalies **O1** and **O2** may represent small areas of structural remains possibly relating to a previous garden layout due to their close proximity and orientation to the pathway.

Moderate high resistance area anomaly of possible archaeological origin
Two areas of moderate high resistance can be identified along the western side of the survey area (**P** and **Q**). These anomalies may represent weak structural remains of archaeological origin.

Low resistance area anomaly relating to pathway
A low resistance area anomaly has been identified running down the approximate centre of the survey area and is related to the pathway that is also present on the 1891 Ordnance Survey map.

Low resistance area anomalies of unknown origin
Three low resistance area anomalies can be identified along the western side of the survey area (**R1-3**). These anomalies may represent areas of depressed ground, cut features or areas of slight water logging.

Faint low resistance area anomalies of unknown origin
In the southwest of the survey area, three faint low resistant area anomalies have been identified (**U1-3**). These anomalies may represent weak evidence for cut features possible relating to a previous garden layout.

4.2 GPR

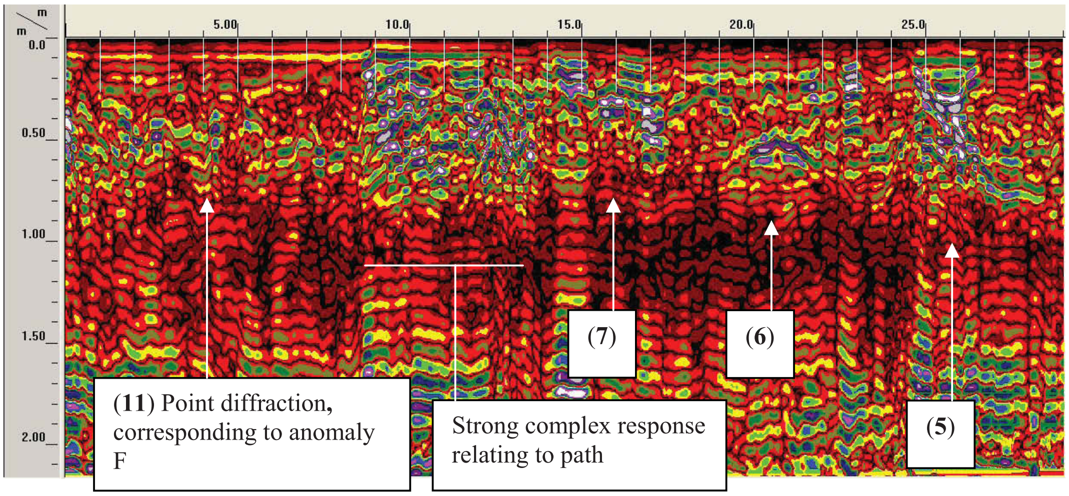
A wide range of anomalies have been identified in all three survey area. The mansion survey (Area 1) has produced the most complex area of anomalies and corresponds with anomalies identified within the resistivity survey. The tilt yard survey (Area 2) has produced large shallow areas of complex returns. Area 3, west of the house, has produced mainly weak discrete and planar responses and has identified a number of possible services.

The anomalies identified have been grouped into the following categories (see Figure 12*)*:

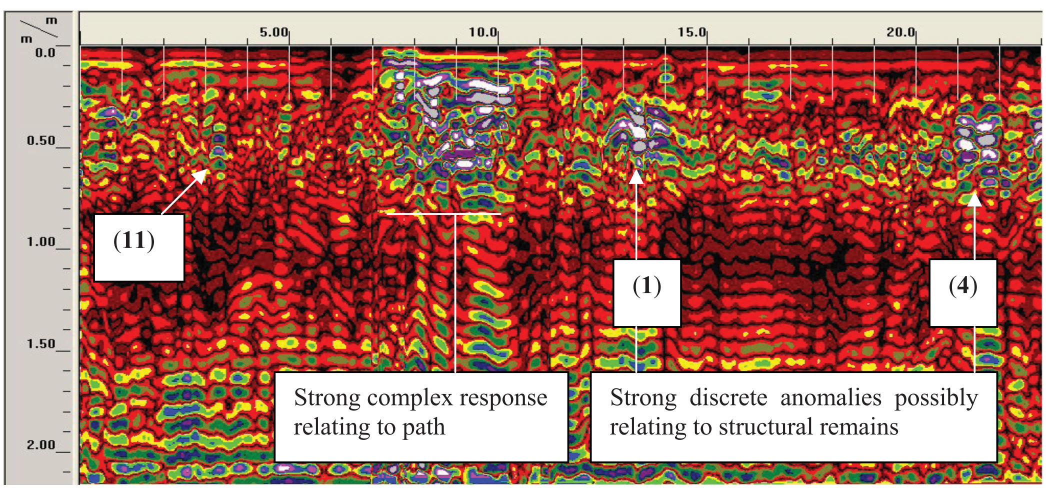
- Linear anomalies possibly relating to structural remains
- Strong discrete and broad crested anomalies – possible evidence for structural remains
- Broad crested anomalies – possible evidence for structural remains
- Strong discrete anomalies – possible evidence for structural remains
- Weak discrete anomalies – weak evidence for structural remains or relating to archaeological activity
- Weak planar and discrete anomaly – weak evidence possible relating to archaeological activity
- Strong complex and discrete anomalies – possibly relating to structural remains or debris
- Shallow strong complex and discrete anomalies – possibly relating to ground disturbance or landscaping
- Weak complex anomalies – possible area of ground disturbance
- Near surface anomalies caused by footpaths
- Possible service

Linear anomalies possibly relating to structural remains

In the west of Area 1 two linear anomalies have been identified at an approximate depth of 0.35m (**11** and **18**). These anomalies may relate to structural remains of archaeological origin (see Example Radargram 1). Anomaly **11** corresponds to the western edge of anomaly **F** identified within the resistivity data.



Example Radargram 1: Area 1 along traverse 14.5N, 0.5-29.5E. Showing strong complex, discrete (**7** and **5**) and broad crested (**6**) anomalies that may relate to structural remains



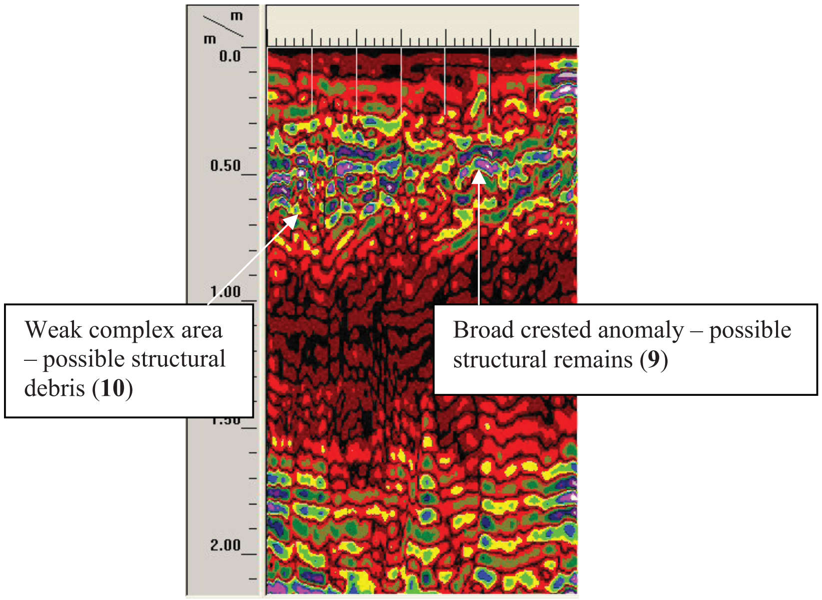
Example Radargram 2: Area 1 along traverse 20.5N, 2-25E. Showing strong discrete (**1** and **4**) anomalies that may relate to structural remains

Strong discrete and broad crested anomalies – possible evidence for structural remains

Situated in the north east of survey Area 1 are a series of broad crested and strong discrete responses at a depth of 0.3m that may relate to structural remains. Anomaly **1** may be associated with anomalies **2** and **3** and correspond to the high resistance anomalies, **A**, **D1** and **D2**.

Broad crested anomalies – possible evidence for structural remains

Broad crested anomalies **6**, **8** and **9** may all relate to possible structural remains at a depth of 0.3-0.42m and corresponds to resistivity anomalies **A**, **C** and **I.** Anomalies **12** and **13** situated in the west of Area 1 may represent structural remains from 0.3-0.6m and may indicate a continuation of linear anomaly **11** and correspond to the high resistance anomaly **F** (see Example Radargram 1 and 3).

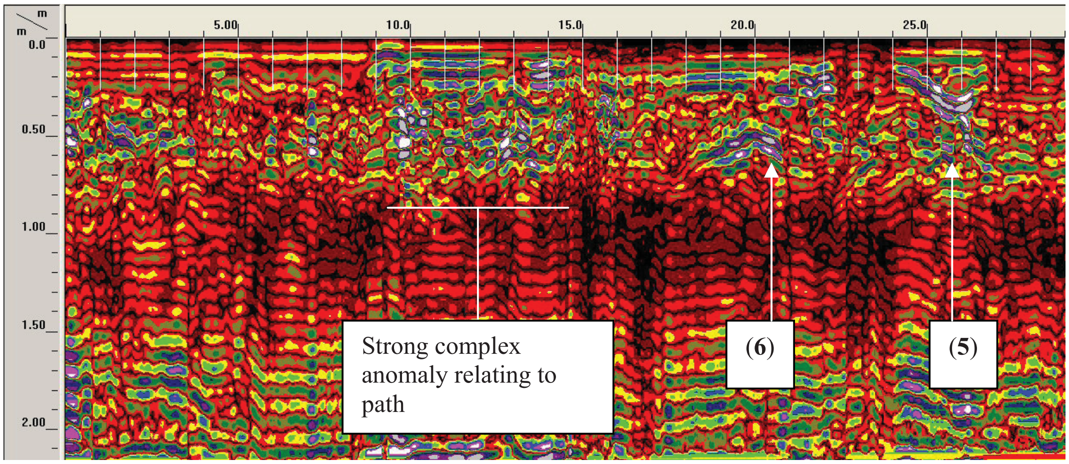


Example Radargram 3: Area 1 along traverse 4.5N, 17-23.5E. Showing a broad crested anomaly that may relate to structural remains (**9**)

Strong discrete anomalies – possible evidence for structural remains

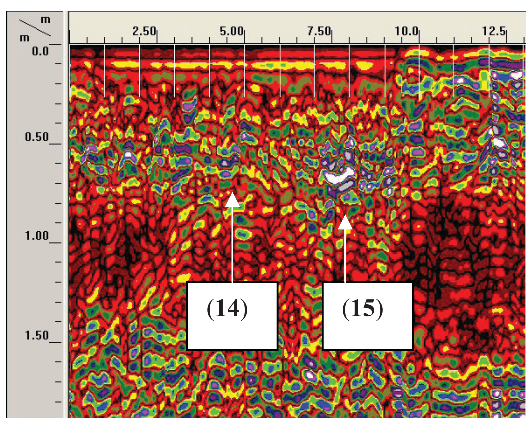
Eight areas of strong discrete anomalies have been identified across the entire survey area. Six are situated within the mansion (**2**, **3**, **4**, **5**, **14** and **15**), whilst two areas have been identified in the north of the tilt yard (**21** and **22**).

Anomalies **2** and **3** may represent possible structural remains and may be associated with anomaly **1**. These features correspond well with the high resistance anomalies **A**, **D1** and **D2**. Strong discrete anomaly **4** corresponds to high resistance anomaly **B** and may represent structural remains of the east external wall. Anomaly **5** may also represent structural remains or debris from the east external wall (Example Radargram 1 and 4).



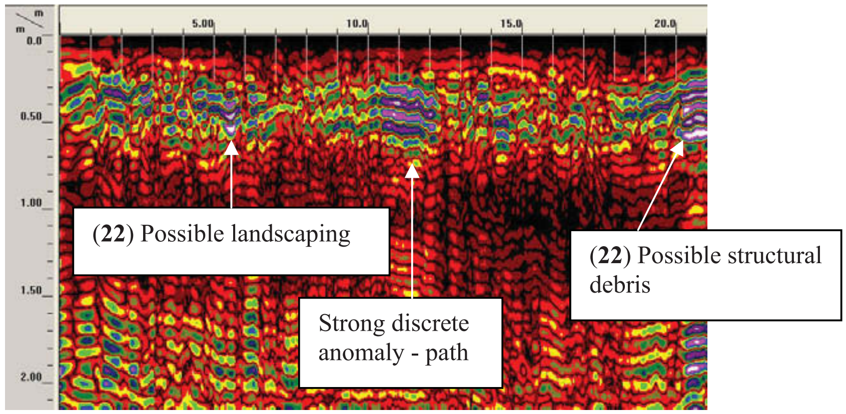
Example Radargram 4: Area 1 along traverse 15N, 0.5-30.5E. Showing strong discrete anomalies that may relate to structural remains (**5**)

Two further strong discrete area anomalies can be identified situated towards the south west corner of the mansion. Anomaly **14** appears at a depth ranging between 0.48-0.9m and may indicate possible structural remains or debris associated with the high resistance anomaly **J**. Anomaly **15** can be identified at a depth of 0.6m and may also represent structural remains of debris associated with resistance anomaly **J** (Example Radargram 5).



Example radargram 5: Area 1 along traverse 2.5N, 0.5-13.5. Showing strong discrete anomalies indicating possible structural remains or debris (**14** and **15**)

Two strong discrete area responses are situated in the northeast and northwest corners of Area 2 at depths between 0.22-0.31m (**21** and **22**). Anomaly **22** may represent an area of structural debris from the mansion. Anomaly **21** may also represent structural remains but may also relate to possible landscaping due to its large and relatively shallow response (Example radargram 6).



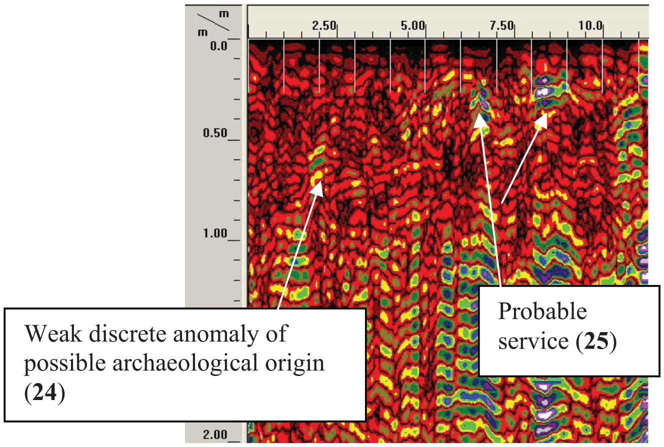
Example Radargram 6: Area 2 along traverse 7.5N, 4-25. Showing strong discrete anomalies possibly associated with structural debris or landscaping (**21** and **22**)

Weak discrete anomalies - weak evidence for structural remains or relating to archaeological activity

Five areas of weak discrete response can be identified within Area 1 (**7**, **17**, **27-29**). These anomalies may represent weak evidence structural remains (anomalies **7**, **17**, **28** and **29**). Anomaly **27** may represent an area of archaeological activity identified at a depth of 0.42m.

Weak planar and discrete anomaly – weak response possibly relating to archaeological activity

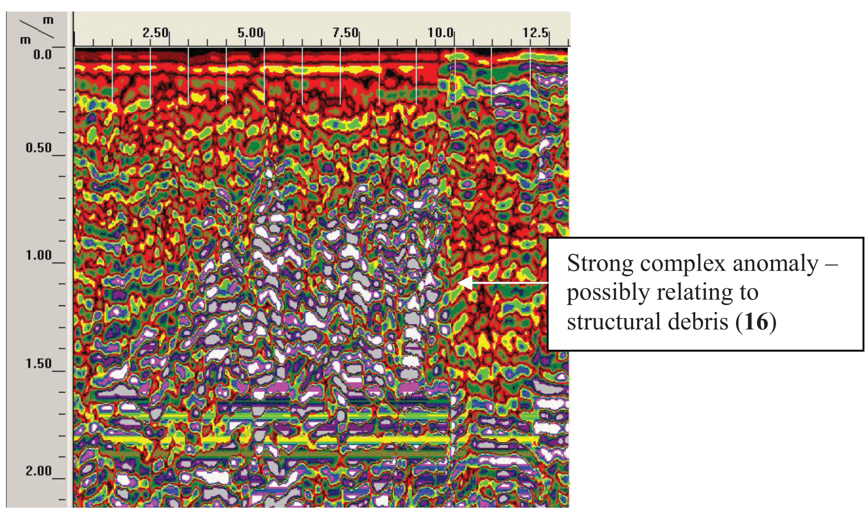
Situated along the western side of Area 3 an area of weak planar and discrete anomalies has been identified (**24**) and suggests weak evidence for archaeological activity. The anomalies abstracted in Area 3 are mainly weak and shallow in depth, suggesting a relatively quite area of archaeological activity compared with Areas 1 and 2 (example Radargram **7**).



Example Radargram 7: Area 3 along traverse 6N, 0-11. Showing a weak discrete anomaly that may suggest archaeological activity (**24**) and anomalies associated with services (**25**)

Strong complex and discrete anomalies – possibly relating to structural remains or debris

Two areas of strong complex and discrete anomalies have been identified along the south and west walls of the mansion (**16** and **19**). These anomalies may represent areas of structural debris. Anomaly **19** corresponds with the low resistance area anomaly **K**, possibly suggesting an associated area of robbed structural debris (Example Radargram 8).



Example Radargram 8: Area 1 along traverse 2N, 0-13. Showing strong complex returns possibly relating to structural debris (**16**)

Shallow strong complex and discrete anomalies – possible ground disturbance or landscaping

Three shallow strong complex anomalies are situated in the west of Area 2 (**20**). These anomalies may represent areas of disturbed ground or landscaping.

Weak complex anomalies – possible area of ground disturbance
Situated in the south east corner of Area 1 is an area of weak complex anomalies ranging in depths of 0.37-0.64m (**10**). These anomalies may represent an area of disturbed ground of possible archaeological origin.

Near surface anomalies caused by footpath
The present pathways situated across Area 1 and 2 have produced a large number of near surface discrete and planar anomalies (see Example Radargrams 1, 2, 4 and 6).

Possible services
Three possible services have been identified with Area 3 (**25** and **26**). The service anomalies **25** are likely to be associated to the nearby inspection cover (Example Radargram 7).

5 CONCLUSION

The resistivity and GPR anomalies appear to correspond well with each other. Both survey techniques have identified a possible number of structural remains that relate to the ruined mansion of Biddulph Old Hall. The majority of these possible structural remains appear at a depth of 0.3m.

The results for the surveys in the tilt yard have provided less detailed results. The resistivity has identified a number of high and low resistance areas with a few faint high resistance linears. The results have targeted areas of possible interest but have identified little in the way of previous structural remains or garden layouts. The GPR has identified areas of possible structural debris and landscaping, the majority of anomalies appear at a depth of 0.2-0.35m.

Few anomalies have been identified within Area 3, west of the present house that may be of archaeological origin. Three possible services have been identified in the northeast corner of the survey area.